

THE STRUCTURE AND BIOLOGY OF *HAEMAPHYSALIS PUNCTATA*, CANESTRINI AND FANZAGO. I.

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Plates XII—XVI.

INTRODUCTION.

THE importance of various species of ticks in relation to the propagation of protozoal diseases, is so generally recognised that it has appeared to us eminently desirable to make a detailed study of one of the common species. Such a study has seemed to us specially necessary for the reason that our knowledge of these parasites is very imperfect, in spite of the fact that they possess an economic interest of the first order. Some of the diseases which ticks transmit, notably those due to the haematozoal parasites belonging to the genus *Piroplasma*, are among the most devastating affections of domesticated animals in many parts of the world, the useful animals which suffer from piroplasmosis being cattle, sheep, goats, horses, and dogs. The disease known as "Heart-water," occurring in South Africa and affecting sheep, goats and cattle, is likewise tick-transmitted. A disease of the domesticated fowl, analogous to relapsing fever in man, likewise of economic importance and occurring in different parts of the world, has also been demonstrated to be transmitted from animal to animal through the agency of ticks. The fowl disease is due to a *Spirochaeta* which is conveyed by ticks; the same holds for human "tick fever" and a spirochaete infection in cattle occurring in parts of Africa. Recent investigation appears to have clearly established the fact that a tick conveys spotted or Rocky Mountain Fever to man. Moreover it has been claimed that a Nematode worm, the *Filaria perstans*, parasitic in man, undergoes its development in a tick which is capable of conveying the parasite from one human

host to another. There can be no doubt but that ticks will be found, upon further investigation, to be associated in the transmission of an increasing number of diseases in animals.

Ticks belong to the class *Arachnoidea*, in which are included the scorpions, spiders and mites, and almost all the members of the class possess eight legs when they reach the adult stage. Ticks constitute a well-defined super-family, the *Ixodoidea*, in the order *Acarina*, and in the light of recent knowledge may be divided into two families, the *Argasidae* and the *Ixodidae*.

It would be out of place to dwell here upon the particular characters possessed by the different genera, especially as these will be duly considered in a systematic work which is being prepared for publication.

The *Ixodoidea*, as far as is known, derive their nourishment entirely by sucking the blood of their hosts. These hosts are almost exclusively terrestrial vertebrates and include practically all classes of Mammalia, Aves, Reptilia (*Chelonia*, *Lacertilia* and *Ophidia*), and Amphibia (*Bufo*). Two species are recorded as attacking Insecta (*Coleoptera*)¹.

The *Ixodoidea* are distinguished from other *Acarina* by their relatively large size; by the position of the spiracles (absent in the larva), situated as they are, in the posterior half of the body, behind the last pair of legs, or as in the *Argasidae* usually between the third and fourth pair of legs; and by the unique structure of the piercing and sucking mouth parts, complicated by the fusion of the basal segments of some of the perioral appendages so as to form a definite structure, the *capitulum*, articulating with the anterior end of the body. The body is compressed dorso-ventrally. The *capitulum* bears two pairs of jointed appendages. On the whole, the *Ixodoidea* are found to agree in their general morphology with the remainder of the order *Acarina*, in so much as the cephalothorax is indistinguishably fused with the abdomen, in the possession of an unsegmented body and in the character of the mouth parts.

The *Ixodidae* resemble each other in all essential characters, but differ from the *Argasidae* in the fact that a hard dorsal shield or *scutum*, absent in the latter, is invariably present in all stages; also the *capitulum* is visible from the dorsal surface in the former, whereas in the latter it is entirely concealed (excepting in the larval stage) by the overhanging anterior extremity of the body: the two families differ also in many respects regarding their habits.

The life-history of the *Ixodidae* may be briefly summarised as follows:—

¹ Neumann 1901, pp. 274 and 294.

The female lays her numerous eggs in the ground. The eggs hatch out in due course and the six-legged larvae issue. The larvae attach themselves to a host and engorge blood, after which, in some cases, they fall to the ground, in others, they remain attached to the host. In all cases, they moult after a time and the eight-legged nymph appears. The nymph either attacks a fresh host or reattaches itself to the original host; it feeds and when gorged drops off, or in certain species, retains its hold. A second metamorphosis takes place and the adult tick, male or female, issues from the nymphal skin.

Copulation takes place upon the host, in some cases (*Ixodes*) it may also take place upon the ground. The males suck blood in moderate amount (a fact often denied), whilst the females become greatly distended with blood which they digest, partially while on the host and partially after dropping to the ground, after which, they lay their eggs in due course, shrivel and die. We shall consider the life-history in detail in our study of *Haemaphysalis punctata*.

Although the genus *Ixodes* is usually regarded as typical of the *Ixodidae* to which it gives its name, we have, for reasons of convenience, chosen a species of the genus *Haemaphysalis* to work upon; we have been able to raise it without difficulty through its various stages under laboratory conditions; also, the species is sufficiently common in Europe to be readily obtained. Most of our material was collected in Kent, the gorged males and females being taken, for the most part, from sheep in the neighbourhood of Romney Marsh.

Before proceeding to a further consideration of the structure of *H. punctata*, we would state that, in common with other *Ixodidae*, the main distinctions between the different stages are as follows:—

The *larva* is a minute six-legged creature, possessing no respiratory (tracheal) system; it has no trace of sexual organs. The scutum covers but a part of the dorsum. When fully gorged, it is about as large as the nymph which subsequently issues.

The *nymph* is larger than the unfed larva; it possesses a tracheal system and a pair of spiracles; also an *Anlage* of the genital system, in the shape of a minute pit at the site of the future genital orifice. The scutum approximates to that of the female. When gorged, it is almost as large as the adult which issues from the nymphal skin. We have been unable to determine any sexual differences in the larval or nymphal stages, but it may be mentioned that nymphs have frequently been mistaken by various authors for "young" females.

The *adult* is larger than the nymph and possesses a well-developed

respiratory system and sexual organs. Both sexes of the ungorged adults are of about the same size; but when fully fed, the female greatly exceeds the male in size. The scutum in the male covers almost the entire dorsum; the anterior portion only, in the female.

In species of *Ixodidae* which possess eyes, they are present, as far as we know, in all the stages, but eyes do not occur at all in the genera *Haemaphysalis*, *Ixodes* and *Aponomma*.

We shall proceed to give a somewhat detailed specific description of *Haemaphysalis punctata*, together with the iconography and distribution.

***Haemaphysalis punctata*, Canestrini and Fanzago, 1877.**

SYNONYMY.

Haemaphysalis punctata, Canestrini and Fanzago, 1877.

Haemaphysalis sulcata, Canestrini and Fanzago, 1877.

Rhipicephalus expositicius, L. Koch, 1877.

Herpetobia sulcata, Canestrini, 1890.

The foregoing synonymy is given by Neumann (1897, p. 327). He includes *Haemaphysalis peregrinus*, Pickard-Cambridge (1889, p. 406), but on referring to the descriptions and figures of the latter author, we were unable to agree with Neumann, for the reason that it was impossible to recognise the tick from the inadequate description. The types, moreover, have been lost.

Haemaphysalis cinnaberina, C. L. Koch, 1844 and 1847, was degraded to *H. punctata* var. *cinnaberina* by Neumann (1905, p. 237), *vide infra*.

Canestrini (1890, p. 526) included *Ixodes chelifer*, Mégnin, 1880, and *Pseudixodes holsatus*, Haller, 1882, in this synonymy, but he was wrong in so doing, as was pointed out by Neumann (1897, pp. 338, 360).

Railliet (1895, p. 714) quotes Canestrini. Neumann (1901, p. 260) considers that *Ixodes testudinarius*, Murray (1877, p. 192), which Murray makes synonymous with *Ixodes marginatus*, Leach, to be probably *H. punctata*. He appears to base this opinion on a figure of Murray's which seems to us to be quite unrecognisable.

DESCRIPTION AND ICONOGRAPHY.

Canestrini and Fanzago's original description (1877, p. 121 repr. and 1877—78, p. 189) refers only to the ♂ and ♀, and is so brief that it would be impossible to identify the species by it. The description

given by L. Koch (1877, pp. 196—198) of *Rhipicephalus expositicius* certainly agrees very closely with that of *H. punctata*, but he gives no figure. Canestrini (1890, pp. 523—526) subsequently gave a more detailed and fairly accurate description, more especially of the ♀; he gives the first figures published (Pl. 41, Figs 6 and 6a), showing a ventral view of the ♂ and a ventral view of the ♂ capitulum. Although inaccurate, Canestrini's figures show the principal ♂ characters. All the points in his description, with the exception of a few measurements, are included in Neumann's description (1897, pp. 327—330). Berlese (1891, Fasc. 55, Pl. 1) gives a coloured figure of *H. sulcata*, together with outlines of the dorsal and ventral aspects of the capitulum and of the spiracle. To us there appears to be no doubt that he was dealing with a gorged nymph of *H. punctata*, although he omits the cornua on the basis capituli and places the chelicerae ventrally instead of dorsally in his figure of the capitulum. In a later publication (1891, Fasc. 58, Pl. 10) he gives an inaccurate coloured figure of *H. punctata* ♂, and equally inaccurate contour figures of the ♂ (ventral aspect), ♂ capitulum and palp, ♀ (dorsal and ventral), ♂ and ♀ spiracles. Finally, Neumann (1897, Figs. 1 and 2, p. 328) figures the hypostome accurately and gives dorsal views of the ♂ and ♀ chelicerae of the left side. His figure of the ♂ chelicera is correct (compare with our Pl. XIV, Fig. 4 and XV, Figs. 5, 6) but that of the ♀ is inaccurate, more particularly with regard to the so-called third apophysis (dorsal process). Wheler (1906, Figs. 30—32) has published photographs of the ♂ and ♀.

SPECIFIC DESCRIPTION.

Female (Plate XIII).

Unfed. Length (anterior margin of scutum to posterior margin) 2·73—3·23 mm. Breadth (maximum), 1·78—2·08 mm.

Body¹ flattened, contour ellipsoidal; reddish-brown dorsally, paler ventrally; glabrous (few excessively minute scattered hairs); *marginal grooves* deep, sharply defined, extending from external angles of scutum, anteriorly, to 4th festoon on either side, posteriorly: *postero-median groove* shallow, extends from median festoon almost to posterior margin of scutum; *accessory grooves* as long as *postero-median groove*, wide and shallow: *foveae* opposite legs IV, darker in colour than surrounding

¹ Refer to text figures 1, 2, p. 165.

parts: *festoons* rectangular, twice as broad as long, nos. 1, 2, and 3 only, on each side, divided by the marginal groove from rest of body. *Scutum*, length 1·08—1·37 mm., breadth 1·05—1·31 mm.; broadly elliptical with flattened postero-lateral margins; dark reddish-brown with darker irregular markings; deeply emarginate anteriorly for reception of basis capituli; surface polished, traversed by minute irregular radiating furrows; punctations irregularly scattered, few in number: *cervical grooves* deep anteriorly, shallow and wider posteriorly, almost parallel throughout their length. *Venter*:—*spiracles* nearly circular, external margin flattened, macula large and slightly eccentric: *genital grooves* divergent, do not quite reach festoons posteriorly: *genital orifice* opposite interspace between Coxae II and III: *anus* nearly circular; *valves*¹ punctate and bearing 5 minute hairs on each: *anal groove* well-marked, bifurcated at its anterior extremity in the form of a Y, the forks of which encircle the anus on either side and terminate in the genital grooves.

Capitulum (see text figs. 3—9, p. 169 et seq.): length, 770—880 μ (from line joining tips of palps to line joining extreme postero-lateral angles of basis capituli): *basis capituli* rectangular, cornua obsolete; *porose areas* large, well separated, rather wider than long; ridge on ventral surface semicircular in contour: *palps* valvate, sub-conical, truncated; article 1 small, almost entirely concealed within the basis capituli, article 2 contracted proximally, much widened out distally with a prominent ridge running round its ventral, lateral and dorsal surfaces and forming the external angle of the palp; infra-internal margin furnished with a continuous fringe of feather-like hairs, usually thirteen in number but subject to some variation; three similar hairs on corresponding margin of third article, the ventral surface of which is produced as a large pointed backwardly directed protuberance; article 4 small and stumpy, with a tuft of stiff hairs on its free extremity, Neumann (1897, p. 328) gives the number of these hairs on the fourth segment of the palp as six; we have found eight to ten such hairs, but the number does not appear to be by any means constant): *chelicerae*: *internal article* with large base and prolonged as a single cutting-lanceet with an outwardly turned point; *dorsal process* crescentic with the points folded towards each other; *external article* a flattened plate with four (sometimes five) outwardly directed cusps, the first of which is the smallest, the others gradually increasing in size to the largest

¹ Neumann (1897, p. 328) says that the anal valves are punctate, but without hairs: we have invariably found five minute hairs on each valve in addition to punctations.

proximal cusp: *hypostome* spatulate, five files of sharply pointed teeth on each half (we have found a slight degree of variation in this respect, the specimen selected for the figure, Pl. XIV, Fig. 2, possessing an irregular sixth file on the right half of the hypostome; we have also seen a female of *H. punctata* possessing six complete rows of teeth on either half of the hypostome); the anterior, median and posterior teeth are smaller than the rest; *corona* well-developed, studded with minute denticles (the corona is frequently curled over on to the dorsal surface of the hypostome and may escape observation if the curling is extreme).

Legs of moderate length, dark-brown, strong; *coxae* slightly longer than wide, each bearing a short wide spur at the posterior margin, near the internal angle; *tarsi* relatively short, spurred, the single spur on each being terminal: *pulvilli* of medium size; two-thirds length of claws. (Canestrini (1890) gives the length of the legs as follows: Pair I = 2·95 mm., II = 2·50 mm., III = 2·5 mm., IV = 2 mm.)

Gorged (Pl. XIII). *Body* oval, more or less distended, may attain a size of 12 × 7·5 mm. (Canestrini, 1890); colour variable—light steel-grey, slate-grey, brownish or brownish-black, yellowish streaks and irregular markings present according to the condition of distension of the Malpighian tubes; dorsal and ventral surfaces punctate: *marginal grooves* and *festoons* obliterated; *postero-median* and *accessory grooves* well defined; anterior to these, four short almost parallel grooves, the outermost of which are often interrupted at the middle of their length (Pl. XIII). *Venter*:—*post-anal groove* not so sharply defined as in unfed ♀ and its bifurcated anterior extremity is obliterated: two dimple-like depressions, one on either side of post-anal groove: *genital orifice* slightly anterior to level of *coxae II*, but position varies according to the state of engorgement, being pushed more and more forward until oviposition commences, when it lies nearly at the base of the capitulum. Otherwise as in ungorged ♀.

Male (Plate XIII).

Unfed. Length (measured as in female) 2·6—3·27 mm., breadth (maximum) 1·67—2·04 mm.

Body ellipsoidal in contour, wider behind than in front, convex dorsally, concave ventrally: *scutum* covers entire dorsal surface; dark reddish-brown with darker, almost black irregular markings; glabrous and polished; punctations fine, numerous, regularly distributed; *scapular angles* narrow; *cervical grooves* deep anteriorly, shallow and divergent posteriorly; *marginal grooves* narrow, sharply defined,

terminating anteriorly opposite leg II, posteriorly at 4th festoon; *accessory grooves* shallow, deeper at posterior extremity; *foveae* in small depressions opposite interspace between legs III and IV. *Venter*:—*spiracles* oval, wider in front than behind, external margin almost straight, postero-marginal angle pronounced; *macula* small, situated towards antero-internal angle: *genital grooves* almost parallel anteriorly, divergent behind coxae IV, extend to posterior marginal festoons; *post-anal groove* straight, bifurcated at its anterior end as in female: *festoons* sharply divided from body by a deep groove: *genital orifice* opposite coxae II: *anus* as in female.

Capitulum, length 500—670 μ (measured as in female): *basis capituli* rectangular, relatively longer than that of female; dorsal ridge with salient rounded angles (*cornua*) at its extremities; few coarse scattered pores on site of porose areas of female: *palps* relatively shorter than those of the female, more conical and less truncated; retrograde spine on ventral surface of article 3 more pronounced: *chelicerae*—*internal article* as in female; *dorsal process* with single large outwardly directed cusp from which a thin strap-like process runs down the dorso-external margin of the internal article and becomes indistinguishably fused with it; *external article* small, with three cusps, the most proximal of which is large and strong: *hypostome* less spatulate than that of female, otherwise similar.

Legs I—III with well-marked blunt *coxal spurs*; leg IV with elongated sabre-shaped coxal spur directed backwards and curving inwards, equal in length at least to that of the coxa: a short blunt backwardly directed spur on the dorsal side of the trochanter of leg I; *tarsi* as in female; Neumann (1897) observes that the tarsi IV of the ♂ *Haemaphysalis punctata* are bicalcarate, a point which we have failed to confirm.

Gorged (Pl. XIII). Alteration so slight as not to necessitate description.

Nymph (Plate XIII).

Unfed. Length: tips of palps to posterior margin 1·39—1·55 mm. (measured as in adult), breadth 1·12—1·31 mm.

Body—oval, flattened, colour varying from pale yellow to brownish-red: *scutum* sometimes broader than long (length 0·37—0·55 mm., breadth, 0·47—0·57 mm.); more rounded than that of ♀; few scattered punctations; divided into minute polygonal areas by a fine reticulum of superficial fissures; otherwise like that of ♀: *grooves* on dorsum similar

to those of ♀ : *foveae* extremely small. *Venter* resembles that of female, the *genital orifice* being represented by a small imperforate pit: *spiracles* almost circular; *macula* excentric, situated towards the inner margin of the spiracle.

Capitulum—length (from tips of palps to postero-dorsal ridge) 0·23—0·29 mm.: *basis capituli* widest at base of palps; dorsal surface extended laterally on either side as a triangular process with rounded point; *porose areas* absent: *palps* longer than hypostome, of elongated triangular form; prominent external angle on article 2, which bears on its infra-internal margin a fringe of about 5 feather-like hairs; article 3 carries a single feather-like hair in a corresponding position: *chelicerae*—*digit* as in female: *hypostome* slightly spatulate; two files of teeth on each half.

Legs paler in colour than in adult; no tarsal spurs; otherwise as in adult.

Gorged. The changes undergone by the nymph during engorgement are similar to those of the ♀, viz. obliteration of the grooves on the surface of the body, alterations in colour, etc. When replete the nymph measures 3·3 × 2 mm.

Larva (Plate XII).

Unfed. Length (tips of palps to posterior margin) 0·58—0·70 mm., breadth (maximum) 0·43—0·48 mm.

Body oval, wider posteriorly, less flattened than other stages; colour dull ochre-yellow; few pale-coloured hairs, regularly arranged (see Figs. 1 and 2); *scutum* broader than long (length, 0·25 mm., breadth, 0·32 mm.); reddish-brown in colour, contour follows that of body in anterior half, postero-lateral margins almost straight, with large rounded postero-median angle; surface reticulated as in nymph; *cervical grooves* deep, straight and not extending to posterior margin: *foveae* absent; *postero-median* and *accessory* grooves faintly marked. *Venter*:—*post-anal groove* slight; *genital grooves* absent: *spiracles* absent.

Capitulum, length (tips of palps to dorsal ridge) 0·15 mm.: *basis capituli* as in nymph but lateral angles less pronounced: *palps* triangular, external angle not prominent; all articles fused together with the exception of the 4th, which is relatively larger and more terminal in position than in the other stages; a single feather-like hair is carried on the infra-internal margin: digits of *chelicerae* as in nymph and female: *hypostome* with four files of teeth, two on each half.

Legs, pale ochre-yellow; no spurs on coxae or tarsi; *pulvilli* relatively larger than in other stages.

Gorged. Beyond the distension of the body, the changes during and after engorgement in the larva do not call for any special reference. A noteworthy feature is the fact that larvae of *H. punctata*, taken from inside the ears of rabbits, when fully gorged are a clear straw-yellow in colour, from which it would appear that lymph and not blood had been ingested.

Haemaphysalis punctata var. **cinnaberina** (C. L. Koch),
Neumann 1905.

This variety, based on a single young ♀, is distinguished from the typical *H. punctata* by the presence of a white chitinous circle round the genital orifice and also round the anus. The type, a dried specimen, from Pará, Brazil, is in the R. Lucas Collection (Berlin Mus.) where it was examined by Neumann (1897, p. 331), who first described it as *H. cinnaberina*, C. L. Koch, but subsequently degraded it to a variety. This tick was inadequately described and figured by C. L. Koch (1844, p. 237; 1847, p. 123 and Pl. XXVI, fig. 97).

**GEOGRAPHICAL DISTRIBUTION OF *HAEMAPHYSALIS PUNCTATA*.
HOSTS ATTACKED.**

Canestrini (1890, p. 525) and Berlese say that this species is fairly common on sheep in Italy; also on goats and fallow deer. L. Koch found a ♂ in a wood near Nürnberg, and named it *Rhipicephalus expositicius*. Neumann has males collected by Colin on a bull (Railliet Coll.): one ♂ and 4 ♀'s from Digne, Beaune, Corsica (Simon Coll.): 2 ♀'s and 1 ♂ from Villefranche found on a horse (Aveyron): 5 ♀'s and 6 ♂'s from sheep and ox at Ste. Jean de Luz: 1 ♀ and many larvae from sheep in England (B. A. I. Coll., Washington, D.C.): 1 ♀ on *Numenius arquata* and 1 nymph on *Otus otus* at Utrecht (Oudemans Coll.): 2 ♀'s at Jassy, Roumania (Leon Coll.): 1 at Fiume, Croatia (Simon Coll.): 1 found under stones and 1 ♀ on a lizard, *Acanthodactylus vulgaris* at Oran (Domergue): 1 ♀ on a bull at Blida, another on a goat at Medea, 1 from Marnia, 1 from a sheep in Egypt (Smithsonian Inst. Coll. Washington): 1 ♂ and 1 ♀ from Orotava, Teneriffe, and 1 ♀ from Funchal, Madeira (Kraepelin Coll. Hamburg Mus.): 5 ♀'s from Canary Islands (Paris Mus.): 1 ♀ from a horse in Aomori, Japan. According

to Neumann, *H. punctata* is sufficiently cosmopolitan but does not appear with frequency; the specimens collected are never very numerous. Canestrini and Berlese found nymph and larvae in Italy, on *Lacerta viridis* and in Dalmatia on *Lacerta muralis* var. *pelagosa*. Neumann's specimens came from a lizard in the Island of Cyprus, and from horse, hare, red partridge and grey partridge (Aveyron).

Since Neumann's description appeared, *H. punctata* has again been recorded in England by Pocock (1900, p. 326), who states that the specimens were collected by Mr F. Pickard-Cambridge at Dungeness, on a hedgehog and amongst shingle on the beach. Neumann (1901, p. 260) records 11 ♀'s, in 5 lots, of which one lot is at the Hamburg Museum and four at the Berlin Museum, which were derived from Athens, Crete, the Cyclades, Teneriffe and Japan: 9 nymphs found on *Lacerta ocellata* var. *tingitana*, were collected by Domergue at Djebel Ksel in Algeria: 3 nymphs were found on *Vipera aspis* by C. Parona at Genoa; 1 ♀ found on the hedgehog by Oudemans in Holland.

In the course of the last few years, we have received large numbers of specimens from Kent, especially the districts surrounding Lydd and Canterbury: the great majority of these were taken from sheep, but specimens taken from goats and ferrets have been received.

TECHNIQUE AND METHODS.

In the study of the external anatomy of *Haemaphysalis punctata*, the authors have examined living specimens; killed, cleared and mounted entire in various media; dissections and sections. The coloured figures are faithful reproductions of living specimens, the original drawings of which were made by means of the Abbe camera lucida and amplified by numerous sketches of mounted specimens.

The Zeiss binocular dissecting microscope has proved itself of the greatest value in the making of fine dissections and in the execution of sketches of the living tick.

Specimens intended for the study of the structure of the chitinous exoskeleton were usually treated with a cold 10 % solution of potash for some hours, or until the soft parts were entirely dissolved, washed in distilled water containing a trace of acetic acid, stained with picric acid, orange G or osmic acid (1 % aqueous solution), dehydrated by transference through graded alcohols, cleared in xylol or oil of cloves and mounted in Canada balsam. It was found that the chitin was efficiently stained by immersion for one minute in xylol saturated with

picroic acid, immediately before the final clearing. Absolute phenol has been of great use in clearing entire specimens, the procedure being to melt a small quantity in a bottle or a watchglass in the embedding oven; drop the specimen in, leaving it until sufficiently cleared; transfer to xylol and mount in Canada balsam. The advantages of this method are the saving of time, the clean results, and the fact that the specimen is completely cleared before the soft parts are disintegrated—a useful feature in the study of the relationship between the exoskeleton and the internal structures.

Glycerine, glycerine jelly and especially monobromide of naphthalene have been used with advantage as mounting media in the study of the structure of the almost colourless, highly refractive chitinous parts, such as the digits of the chelicerae and the pulvilli. Minute dissections were made, as a rule, in oil of cloves, a method which facilitates manipulation with mounted needles. In the preparation of material for section cutting, all the better known fixing reagents have been tried, but the majority rendered the chitin so brittle that success was impossible. The reagent which has given satisfactory results is picro-sulphuric acid (Kleinenberg's formula). This is used in the undiluted condition and is heated to about 90° C. before immersing the material. The time required for complete penetration varies, but gorged females of *H. punctata* have been found to be thoroughly permeated with the reagent after an immersion of 1—2 minutes.

The authors intend to consider the subject in greater detail in the section dealing with the internal anatomy and histology.

For many purposes, photomicrography has lent assistance, but with few exceptions drawings alone have been used for illustration.

In the work on the structure of the external parts, considerable difficulty was experienced in obtaining proper orientation and fixation of the more minute parts for the purpose of drawing: this led the authors to try various plastic materials in which the part to be investigated could be lightly embedded and then orientated under the microscope, by means of mounted needles. The preparation known as Plasticine has proved an admirable medium for this purpose, and its use can be recommended in all cases where it is desirable to examine opaque objects which, on account of their form, are difficult or impossible to fix in proper position without resort to some such means.

TERMINOLOGY.

One of the first features which strikes a reader, in perusing the published literature, is the hopeless confusion wrought by the loose use of terms, taken for the most part from the nomenclature used in the description of other classes of the animal kingdom, more particularly the Insecta.

As an example one might mention the *hypostome*, to which names innumerable have been applied, many of them being unsupported by morphological relationship; thus creating erroneous impressions of the homologies of this structure. Thus the *hypostome* has been called :—

(1) <i>Lingua.</i>	(5) <i>Maxilla.</i>
(2) <i>Maxillo-labial dart.</i>	(6) <i>Labium.</i>
(3) <i>Glossoide.</i>	(7) <i>Radula.</i>
(4) <i>Ligula.</i>	(8) <i>Languette.</i>

With a view of obviating some of this confusion, we have been reluctantly compelled to add more terms to the already excessive number : in other cases a selection has been made from the existing nomenclature of those which have appeared to be the most suitable.

A list of the terms used, together with synonyms, will be appended at the end of this work.

General Body-form.

Haemaphysalis punctata presents no marked structural differences from the rest of the *Ixodidae*. The *body* is roughly elliptical in contour, flattened dorso-ventrally, slightly concave on the ventral surface and convex on the dorsal surface in unfed specimens. It shows no differentiation into *cephalothorax* and *abdomen*. Deeply implanted into a special opening at the anterior end of the body is the *capitulum*: this structure, frequently referred to as the "head," is not such in a morphological sense, the true head of the tick comprising parts lying posterior to this and indistinguishably fused with the rest of the body. The *capitulum* is a very specialised structure, freely articulated with the body and bearing the oral opening together with its accompanying appendages. The *mouth* is not visible on external examination, being concealed between the median *hypostome*, ventrally, the *palps* laterally, and the paired *chelicerae*, dorsally. The *palps* are situated on either side of the *hypostome* and *chelicerae* and when adducted, ensheathe and protect these medianally-placed appendages.

Key Figures to nomenclature of parts.

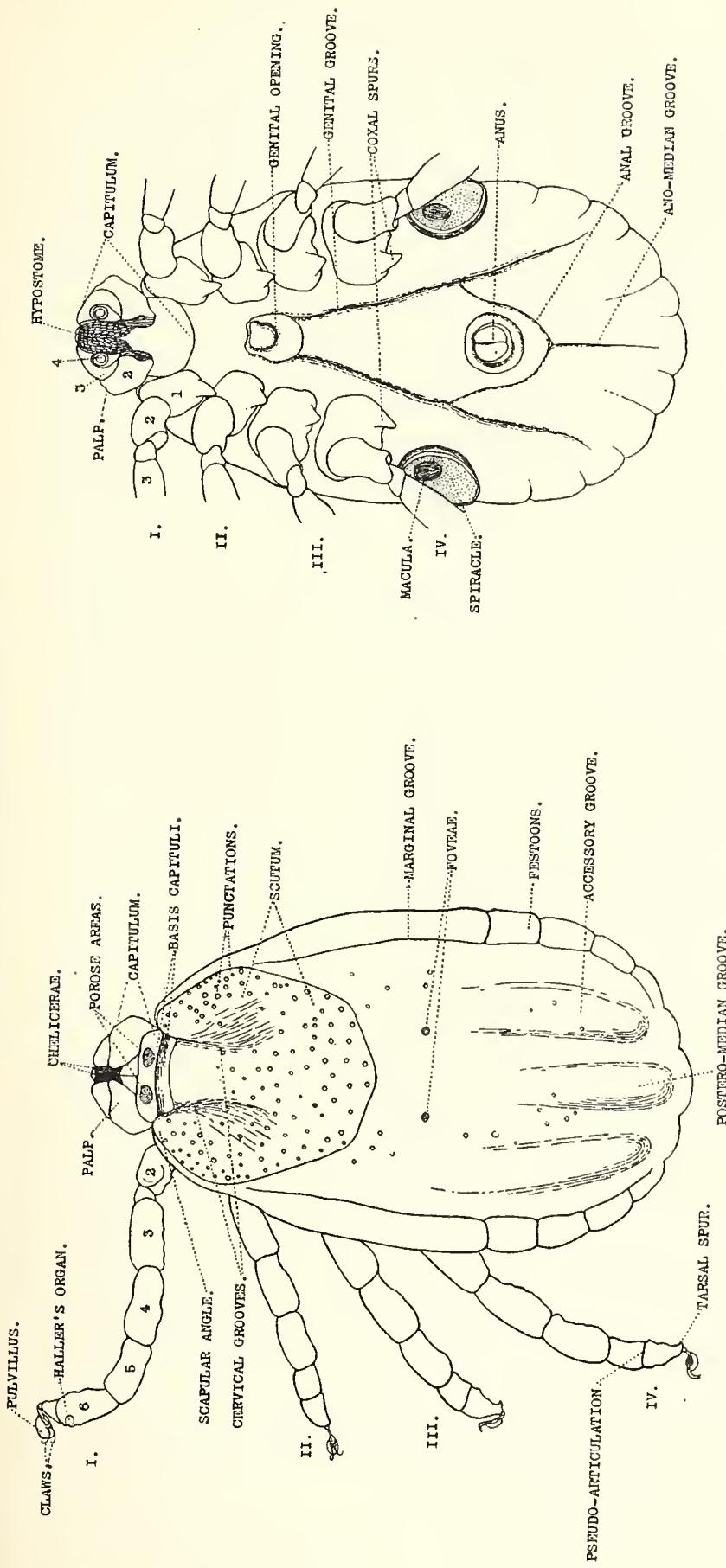


Fig. 1. *Haemaphysalis punctata*. ♀. Dorsal aspect showing the principal external features. The capitulum, on account of its downward inclination, is foreshortened. L.E.R.

Fig. 2. *Haemaphysalis punctata*. ♀. Ventral aspect. L.E.R.
The roman numerals indicate the legs, the arabic figures the segments, of the appendages.

It may be said that the body shows no marked trace of segmentation in either the nymphal or adult stages, but in the larva at any rate, the arrangement of the hairs and pores indicates a certain amount of metamerism; possibly the crowding of these tegumental structures in the later stages of the life-history may obscure any such appearance. The regular postero-marginal indentations of the body-contour in all the stages also seem to point to a feeble persistence of segmentation of the abdomen. We have reason to believe, after an examination of the embryo of this species, that at an early period of the development, some five or six segments appear in the body, posterior to the last pair of limb-buds. The exact significance of these phenomena we hope to determine later, when we have an opportunity of devoting more time to the embryology of the *Ixodoidea*¹.

The dorsal surface of the body is covered almost entirely in the male and the anterior half only in the female, nymph and larva, with a plate of chitin which is denser, harder and more deeply pigmented than the general body chitin; this structure which is present in all ticks with the exception of the *Argasidae* is termed the *scutum*.

In many genera of ticks, the scutum bears the single pair of eyes, one on either lateral margin; in *Haemaphysalis*, however, as in the genera *Ixodes* and *Aponomma*, no trace of these organs exists.

On the ventral surface of the body in its anterior half are borne the legs, four pairs in the adult and nymph, and three pairs in the larva. Each leg is comprised of about six articles, all of which are freely movable with the exception of the most proximal article or *coxa*. Each of the legs carries at its extremity a foot provided with two long curved claws (*ungues*) and a pad (*pulvillus*).

On the ventral surface of the body in the adult, two large openings are seen in the middle line. The first lies midway between the coxae of the first and second pairs of legs and has the appearance of a transverse slit: this is the *genital orifice*. In the nymph, a minute pit is visible in a corresponding situation which may be considered as an *Anlage* of the genital orifice of the adult. The larva exhibits no trace of such a structure. Some distance posterior to the genital opening, at about the commencement of the posterior third of the body, is the *anus*, a longitudinal slit bounded laterally by a pair of crescentic plates, the *anal valves*, the whole being surrounded by a ring or annulus of thickened chitin.

¹ Wagner J. 1892, p. 319 "Hinter den Beinen liegen 5—6 Mesodermgruppen."

The surface of the body exhibits a number of constantly occurring and well-defined grooves: these are the external indications of the lines of insertion of bands of muscle-fibres which run in a dorso-ventral direction through the body and are attached at either end to the chitinous cuticle. On the ventro-lateral margins of the body, posterior to the coxae of the fourth pair of legs, are situated the paired *spiracles*, a pair of more or less circular, slightly raised plaques of paler colour than the surrounding integument: in the larva, the spiracles and tracheal system are not developed. The posterior contour of the body is deeply indented at regular intervals by short grooves; these run round the margin from the dorsal to the ventral surface and define certain small rectangular marginal areas which are termed *festoons* in descriptive nomenclature. It is worthy of notice that the festoons are frequently more or less obliterated in the female and immature stages, by the distension of the body after engorgement, but although the alteration is not so marked in the male, the appearance of the festoons differs considerably in the unfed and gorged individuals (Pl. XIII). The *cuticle* of the tick is perforated by numerous pores of various forms which serve as a means of communication between certain modified hypodermal cells and the exterior. Numerous hairs are distributed over the different parts of the body; these differ among themselves according to their various functions. Certain areas of the body are glabrous.

The sensory organs are comprised of (1) certain defined areas into which numerous fine pores open, and beneath which the hypodermal layer is specially modified: such organs are found in the female on the dorsal surface of the basis capituli (*porose areas*), and in both sexes on the dorsum, where a pair of minute perforated areas are found, to which the name of *foveae* has been applied; these foveae the authors have found to exist in the nymph but not in the larva: (2) *Haller's organ*, a complex cavity in the cuticle of the tarsal portion of the first pair of legs, which communicates with the exterior by a minute slit-like pore and bears on its floor a number of sensory hairs, but does not contain otoliths¹: (3) *tactile hairs* of different forms, arranged either in a scattered manner or collected into groups.

The tactile sense appears to be the most highly developed, after that the olfactory sense, and in spite of the absence of eyes, as found in some genera of *Ixodoidea*, *H. punctata* is very sensitive to light and in-

¹ We intend to publish an account of the general structure of "Haller's Organ" in different species, in the near future.

variably attempts to remove itself as far as possible from a source of light if exposed.

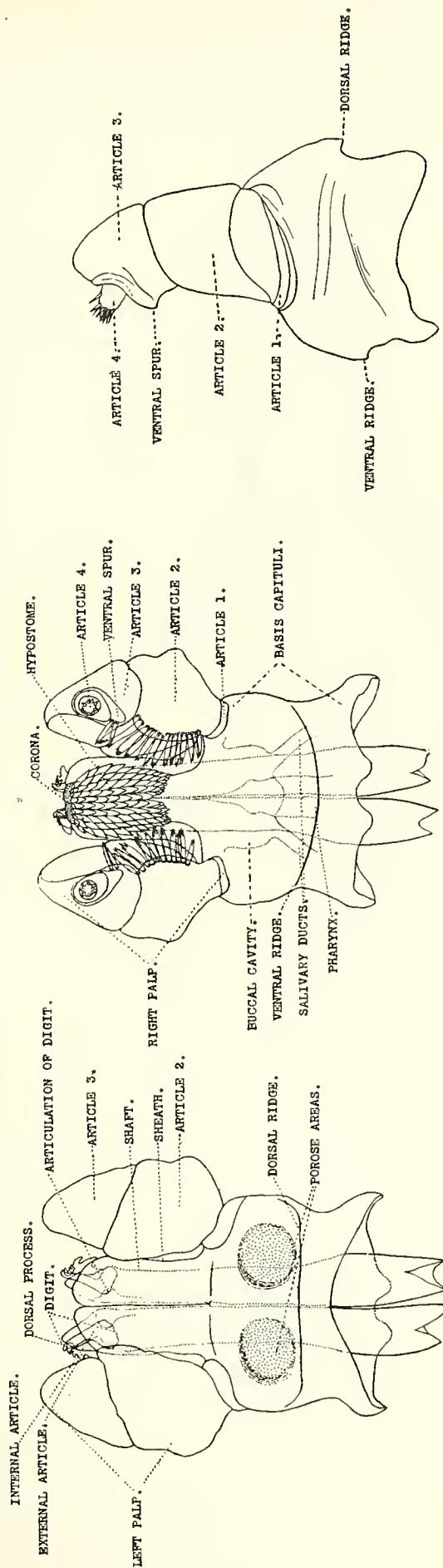
It must be borne in mind, especially in the reading of specific descriptions of *Ixodoidea*, that the general appearance undergoes very considerable transformations during and after engorgement; this is most noticeable in the larva, nymph and female, but the male may be considerably altered (see Pl. XIII). In the matter of colour, the gorged female exhibits any colour from pale greyish-yellow to almost pitchy-black. Prolonged immersion in preservatives, especially in alcohol, may completely modify the original colour, gorged females of *H. punctata* usually acquiring a more or less uniform dark reddish-brown tint.

I. The Capitulum of the Female.

(Plate XIV, Figs. 1 and 2, Text Figs. 3—5.)

The capitulum is the head-like structure, situated at the anterior extremity of the body, upon which is borne the oral opening with its accompanying appendages. The large basal portion, hereafter spoken of as the *basis capituli* (b.c.), is constricted in its posterior half and this neck-like portion is telescoped into the anterior opening of the body cavity. The anterior portion of the basis capituli is roughly rectangular in shape, with flattened surfaces dorsally and laterally, and somewhat convex ventrally. A pronounced salient ridge, the *dorsal ridge* (d.r.), runs transversely across the dorsal surface, which, when the capitulum is raised in a line with the body-axis, comes in contact with the anterior margin of the scutum, the posterior constricted portion being concealed beneath the latter. Ventrally, the anterior portion of the basis capituli is differentiated by another ridge, the *ventral ridge* (v.r.), running in a transverse direction and curved, with its convexity directed posteriorly but not so sharply raised as the dorsal ridge. The sides of the basis capituli are flattened and the dorsal and ventral ridges are not continuous.

At the antero-lateral angles of the basis capituli, deeply implanted into a pair of large rectangular fenestrae, are the *palps* (p.). The ventral surface of the basis capituli is produced anteriorly in the median line as a spoon-shaped prolongation beneath the mouth; this structure is termed the *hypostome* (h.). On its dorsal side, the basis capituli is prolonged between the palps as a pair of parallel tubes which ensheathe the *chelicerae*. The dorsal surface shows a pair of large shallow saucer-like



Figs. 3 and 4. *Haemaphysalis punctata*, ♀. The capitulum seen from the dorsal and ventral aspects respectively. L. E. R.

Fig. 5. *Haemaphysalis punctata*, ♀. Lateral aspect of the capitulum. L. E. R.

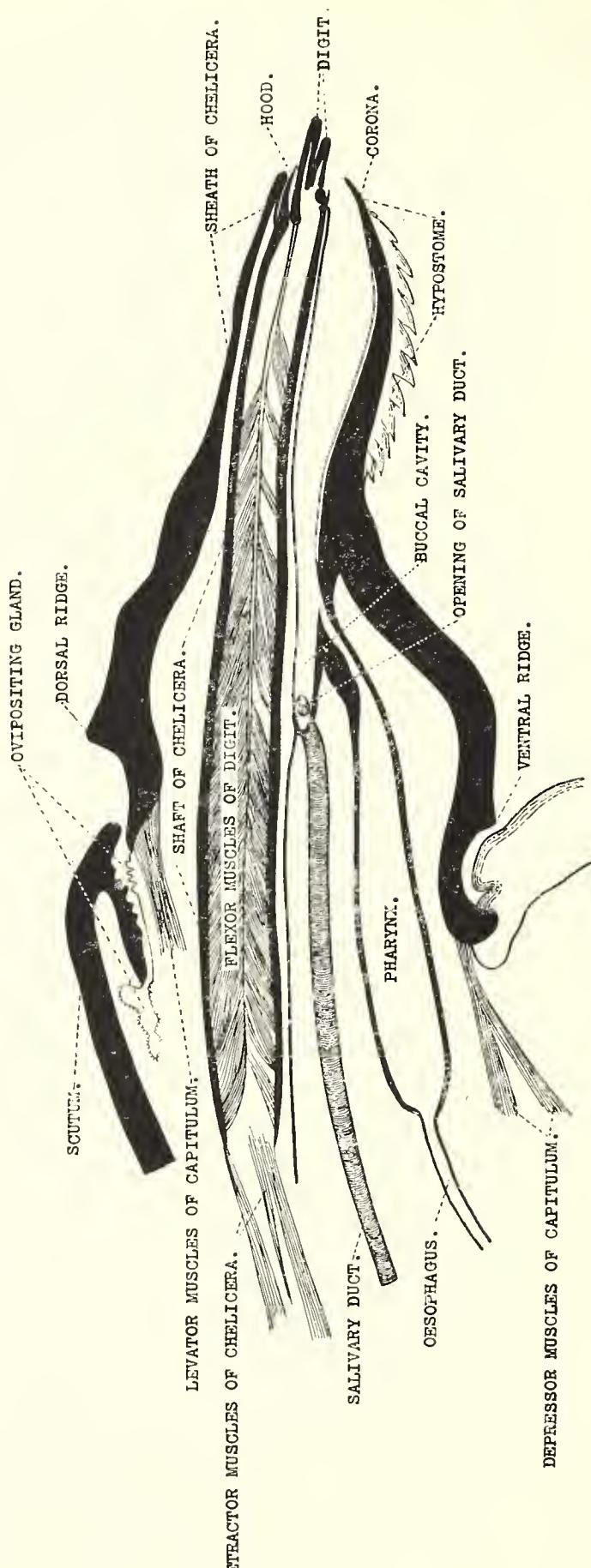


Fig. 6. *Haemaphysalis punctata*, ♀. Median longitudinal section through the capitulum showing the relations between the internal and external parts. Slightly schematized. G. H. F. N. and L. E. R.

depressions into which numerous minute pores open, hence termed the *porose areas* (p.a.); these structures will receive more detailed consideration later, under the heading of organs of the senses. With the exception of two small patches on the ventral surface, beset with minute stumpy hairs, the basis capituli is glabrous.

The chitinous integument of the basis capituli is thick and strong, and is thickened in internal ridges which give the whole structure stiffness and serve for the attachment of the muscles which bring about the movements of the capitular appendages and the *pharynx*.

The *hypostome* (h.), already referred to, is spatulate in outline and consists of a small proximal portion, whose ventral surface is smooth and convex, and a larger distal portion provided on its ventral surface with ten longitudinal files of pointed denticles which overlap one another from before backwards, in the manner of roof-tiles. It is divided along the median line by a fissure, separating the denticles into two series of five files, each file consisting of about twelve denticles. Although the number and arrangement of these denticles are fairly constant, a certain amount of irregularity frequently prevails, especially at the distal and proximal extremities. The denticles differ in size, the anterior and posterior being the smallest and the lateral being the largest. At the free extremity of the hypostome, is a thin plate of chitin continuous with the body of the hypostome, variable in size and studded with minute irregularly arranged denticles; this structure, the *corona* (c.), appears to be relatively larger in the immature stages. The upper surface of the hypostome is concave in a longitudinal direction and convex transversely; running down the median line is a small gutter (see transverse sections Plate XVI, Figs. 1—5), which, when opposed to the sheaths of the chelicerae above, forms a tube leading back to the buccal cavity. A longitudinal ridge runs along the lateral part of the ventral surface of each cheliceral sheath and a pair of slight ridges on the dorsal surface of the hypostome fit within the former, thus effecting a complete lateral closure of the space between the hypostome and chelicerae during the action of sucking (Plate XVI, Figs. 2, 3).

The *chelicerae* (Plate XV, Fig. 4 and Text Figs. 7—9) consist of a pair of more or less cylindrical appendages situated above the mouth. Each consists of a stout external *sheath* (sh.) already described as an anterior prolongation of the basis capituli, within which the chelicera proper lies, and is capable of complete retraction and of a considerable amount of protrusion: the two external sheaths lie in contact with one another throughout their length. The chelicera

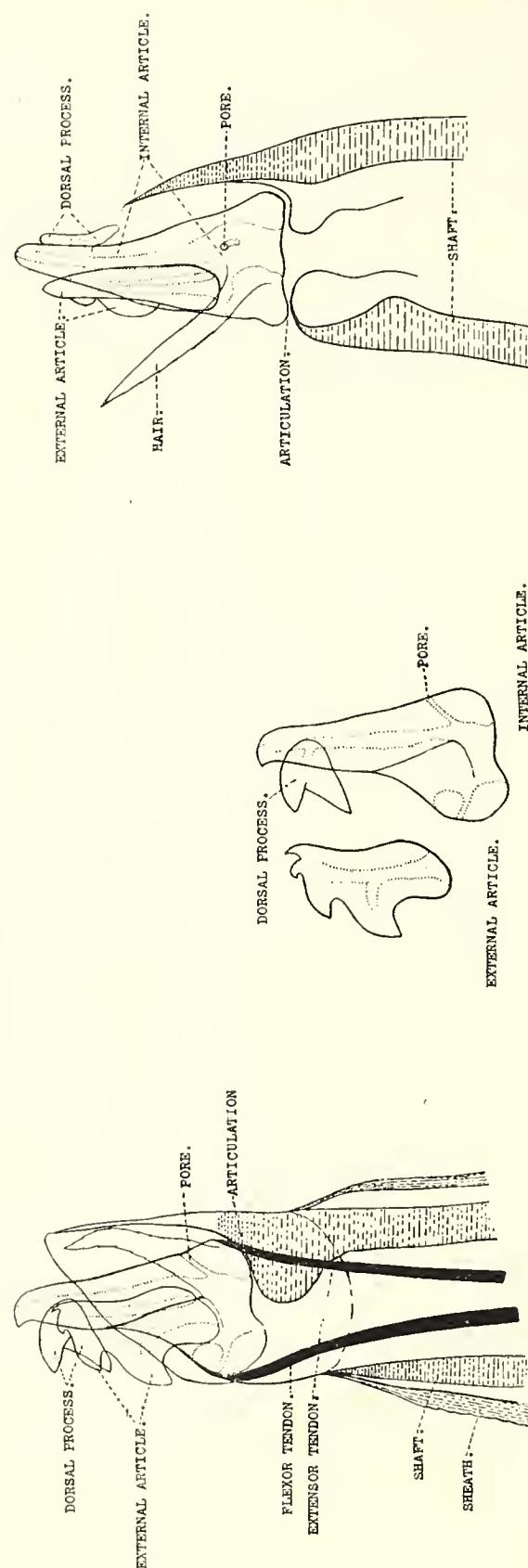


Fig. 7. *Haemaphysalis punctata*. ♀. The distal extremity of the right chelicera, showing the articulation of the digit, etc. L.E.R.

Fig. 8. *Haemaphysalis punctata*. ♀. Right chelicera, the articles isolated. L.E.R.

Fig. 9. *Haemaphysalis punctata*. ♀. Right chelicera, median or internal aspect. L.E.R.

proper consists of a long cylindrical tube, the *shaft* (s.ch.), upon the distal and free extremity of which is borne the chelate *digit* (d.ch.) which constitutes the cutting apparatus by means of which the animal penetrates the skin of its host. The sheath is covered on its dorsal and lateral surfaces, excepting its proximal third, with numerous minute reflexed denticles, regularly arranged in oblique rows and in close contact with one another, giving it an appearance which has suggested the term "shagreened sheath": it is firmly fused with the basis capituli at its proximal end. At its free extremity, the sheath is invaginated and becomes membranous and flexible, and this thin membranous portion is attached to the shaft some little distance posterior to the articulation of the terminal digit, by which arrangement the shaft draws in the extremity of the sheath over the delicate digital structures when fully retracted. The shaft of the chelicera is very long, so long in fact as to project backwards beyond the basis capituli into the body-cavity: it is divided into two portions, differing in diameter. The proximal portion, comprising about one-third of the entire length, has thinner walls than the distal portion and is dilated: the edges of the proximal extremity are irregularly incised and it is to this extremity that the retractor muscles of the chelicera are attached (Text Fig. 6): this dilated portion is occupied by muscles attached to its internal surface and from which proceed the tendons which are inserted into the base of the digit. The distal two-thirds of the shaft is roughly cylindrical with a slight ridge along its supra-internal margin, the ridge being longitudinally traversed by a minute canal (Plate XVI, Figs. 2—9): the chitinous walls are thick and show a delicate transverse striation: the distal extremity is thickened internally and presents a surface for the articulation of the base of the digit. At the junction of the proximal and distal portions of the shaft is a somewhat rectangular area of thinned and membranous chitin, in length about equal to the diameter of the shaft and extending round the dorso-lateral surface of the latter for about half its circumference. The *digit* consists of two movable articles, a larger *internal article* (i.a.), with which is articulated a smaller *external article* (e.a.). The internal article is expanded at its base and articulates directly with the shaft; it is prolonged forwards on the internal side in the form of a long cutting lancet with a slightly hooked extremity, the point of which is directed laterally; it is hollow throughout its length, the cavity in the expanded base being of considerable size. Near the distal extremity of this article, attached to its dorsal surface, is a crescentic chitinous structure with laterally directed points which is

often referred to as the *third apophysis*: it is firmly fused to the internal article, a prolongation of the cavity of which extends into it, and we consider it to be simply an outgrowth of the latter, comparable to similar processes often seen on the homologous articles of the chelicerae in the *Gamasidae* and *Oribatidae*, and for this reason we prefer to term it the *dorsal process* (d.p.). The external article articulates with the expanded base of the internal article; it consists of a flattened plate of chitin, the external margin of which is deeply incised, so as to form a series of four or five pointed cusps, of which the terminal one is the smallest, and the proximal the largest: it is hollow and its internal cavity is continuous with that of the internal article; indistinct channels appear to run out from the central cavity for a short distance along the lateral cusps. In many cases, the cavity of the internal article appears to terminate in a minute pore at the distal extremity; whether this is actually the case we are not in a position to express a definite opinion: it is, however, certain that the interior of the expanded base of the internal article communicates with the exterior by at least two fine channels, one on the internal side and one on the external (pr.), the possible function of which it is difficult to imagine.

The digit of the chelicera is surrounded on its internal side by a delicate hood of thin and very transparent chitin, a prolongation of the shaft of which it is a part; it is tapered away on the external side of the digit in such a manner as to fully expose the cutting parts of the appendage. The internal article bears on its basal portion a single serrate hair, which protrudes between the hood and the lanceet-shaped portion of the former (see Text Figs. 7 and 9 and Pl. XV, Figs. 4—6).

The base of the digit, formed entirely from the expanded portion of the internal article, articulates with the shaft by a rocker-like hinge-joint, the shape of the articular surfaces being such as to limit the movement of the digit to a horizontal plane. The movements of the digit are produced by the tendons, one internal and one external, which originate in the mass of muscle occupying the cavity of the shaft (see Text Fig. 6, p. 170): the internal tendon is inserted into the internal article at its proximo-internal angle, while the external tendon, the stouter of the two, runs partially round the lateral surface of the article and is inserted towards the upper surface of the expanded base.

The palps. These appendages are inserted into the basis capituli at its antero-lateral angles. The general outline of each is that of a truncated cone; the basal portion is much constricted laterally, but not

in the dorso-ventral direction. Each palp is quadriarticulate, but the articles differ greatly in size and form. The proximal or *first article* is very small and is almost entirely hidden within the basis capituli; it is narrow from side to side, elongated in the dorso-ventral direction, and obliquely inclined to a plane at right angles to the long axis of the capitulum in such a manner as to bring its ventral portion posterior to the dorsal portion: externally it is only visible ventrally, being completely hidden on the dorsal side by a scroll-like fold of chitin derived from the basis capituli. The second and third articles constitute the greater portion of the palp. The *second article* is irregular in shape, very convex on its ventral, external and dorsal surfaces and is provided with an oblique ridge (r.) which runs forwards and outwards from the proximo-internal angles and which defines another surface directed backwards. The *third article*, smaller than the second, tapers distally to a blunt rounded extremity which forms the extremity of the palp; on its ventral surface, a little toward the internal margin, it bears a large pear-shaped fossa bounded by a raised margin, the latter being produced postero-internally into a large blunt salient process; in this fossa the comparatively minute *fourth article* is implanted. This article is very short and stumpy and is furnished with a crown of eight to ten short stiff hairs on its distal extremity. The interno-lateral aspect of the second and third articles of the palps is deeply concave, so that when adducted, the two palps ensheathe the chelicerae and hypostome. The infra-internal margin of the palp is furnished with a single row of peculiar flattened feather-like hairs (Pl. XV, Fig. 1); of these hairs, thirteen to fifteen are carried on the second article and about three on the third article: they are directed towards the mid-ventral line of the capitulum, the tips of those of each side almost meeting when the palps are adducted. The surface of the palps is furnished with a few simple hairs and pores.

The *buccal cavity*. The buccal cavity is contained within the anterior part of the basis capituli; it lies between the bases of the palps, behind the hypostome, and is visible through the walls of the basis capituli in cleared specimens as a chitinous mass with a symmetrical outline of somewhat complex shape (the contour is indicated in Pl. XIV, Figs. 1, 2)¹. The walls of the basis capituli, bounding the anterior

¹ On account of the prevailing system of making drawings from specimens cleared and mounted in Canada Balsam or other highly refractive medium, without reference to the untreated specimen, the outline of the buccal cavity and other internal structures have frequently been figured by different authors in illustrations to specific descriptions of the *Ixodidae*. As such figures are usually supposed to represent external structures, the inclu-

margin of the buccal cavity immediately behind the hypostome, are of great thickness, giving increased strength to the anterior part of the basis capituli and firm support to the bases of the mouth appendages; running through these thick walls, ventral to the buccal cavity, is a pair of narrow canals leading to the bases of a single pair of hairs situated on the base of the hypostome. Into the postero-internal angles of the buccal cavity the large cylindrical *salivary ducts* open (s.d.); these are readily recognised by the delicate trachea-like transverse striation of their walls. Opening on the floor of the buccal cavity at its posterior end is the *pharynx*, a longitudinally placed chitinous sac of peculiar shape, which extends backwards into the body-cavity, where it becomes suddenly constricted into the narrow oesophagus. The relation of these parts will be more perfectly understood by reference to the figure showing a schematised longitudinal section through the capitulum (Text Fig. 6, p. 170)¹.

II. The Capitulum of the Male.

(Plate XIV, Figs. 3 and 4.)

The capitulum of the male differs from that of the female in details only, but these are sufficient to necessitate a special description. The dorsal ridge of the basis capituli bears at either lateral extremity, a short backwardly directed process (cornua). The porose areas are absent, a few scattered pores of the ordinary type being present. The palps are shorter and wider in proportion to their length and more pointed at the apex. The number of hairs borne on the infra-internal margins of the second article of the palp is usually thirteen, three being carried on the third article, as in the female. The hypostome is narrower in proportion to its length and not so markedly spatulate: the teeth which beset its ventral surface are also more elongated and sharply pointed. The chelicerae agree in their general structure with those of the female, but the digit calls for special attention. The internal article is similar to that of the female; the external article is relatively smaller in comparison with the internal, and only bears three cusps on its external margin. The dorsal process is quite different from

sion of these outlines is misleading, in the fact that they might be taken to represent external or superficial features.

¹ Nuttall, Cooper and Smedley (1905) described the details of the structure and relationship of the buccal cavity and pharynx; it will be considered again in a future paper which will follow in this *Journal*.

that of the female; it consists of a large triangular process, the shape and disposition of which are seen by reference to the figure (Pls. XIV, Fig. 4 and XV, Figs. 5, 6).

III. The Capitulum of the Nymph.

(Pl. XIV, Figs. 5 and 6.)

The capitulum of the nymph is intermediate in its general appearance between that of the adult and the larva. The salient ridges, seen in the adult on the basis capituli, are fairly well-developed: the anterior portion of the basis capituli is wider in front than behind, and its dorsal surface is produced laterally into large triangular flattened processes with rounded extremities: the postero-lateral angles of the ventral ridge are produced into short rounded backwardly directed processes, which for descriptive purposes we have styled "*cornua*." As in the adult, the basis capituli shows a posterior neck-like constriction immediately behind the dorsal and ventral ridges.

The *hypostome* is less spatulate and is provided on its ventral surface with four rows of denticles, about nine to each row.

The *chelicerae* of the nymph appear to be similar in all respects to those of the female.

The *palps* differ from those of the adult tick. Four articles can be distinguished, but the second and third articles are more or less fused with one another. The first article is very small; is completely concealed within the basis capituli and less readily distinguished than in the adult. The second article is large, and is raised on its ventral, lateral, and dorsal surfaces as a prominent rounded ridge, which forms the pronounced external angle of the palp. The infra-internal margin of this article bears five hairs, flattened and feather-like as in the adult, but wider at their bases and more tapering at their extremities. The third article is conical and forms the extremity of the palp; it is almost completely fused with the second article, the only line of demarcation being found towards the internal margin of the dorsal surface, where a deep indentation in the contour of the edge indicates the commencement of a fissure which is produced round the palp on its dorsal side for a short distance only. A shallow depression runs round the lateral surface of the article, and this, together with the arrangement of the hairs on its proximal side, shows the line of fusion with the second article. The infra-internal margin of the third article carries a single feather-like hair. The fourth article is

similar in form to that of the adult and likewise implanted into an oval fossa on the ventral surface of the third article.

The *porose areas* are absent.

IV. The Capitulum of the Larva.

(Pl. XIV, Figs. 7 and 8.)

The capitulum of the larva differs from that of the other stages in the relatively small size of its palps and in the fact that it is shorter in proportion to its width. The basis capituli is divided on its dorsal surface into anterior and posterior portions by a salient ridge, but unlike the later stages no ridge is developed on the ventral surface, and in addition the posterior portion is not so constricted. As in the nymph, a considerable amount of fusion exists between the articles, so much so in fact that the only free article is the fourth, the first, second and third being solidly fused together.

The *hypostome* is smaller than that of the nymph and bears four files of about six denticles.

The *chelicerae* resemble those of the female and nymph in form, all the structures being fully developed as in the adult (Pl. XV, Fig. 3).

The *palps* are very short and conical, strongly curved laterally and deeply concave on their median faces; the lateral angles are not so pronounced as in the nymph. They show a considerable amount of difference from those of the stages already described; the tendency to fusion of the articles as already shown in the case of the nymph reaches a maximum. Article 1 is very small and is exceedingly difficult to define; it is completely hidden within the basis capituli: articles 2 and 3 are the largest, but it is impossible to say with certainty, whether the line of folding of the cuticle (shown by a line in Pl. XIV, Fig. 7) is the line of fusion of the article: article 4 is relatively large and is more terminal in position than in the later stages.

A single feather-like hair is carried on the infra-internal margin of the palp, and in addition to this all the others, with the exception of the stiff bristle-like hairs on article 4, are serrate on one or both sides, as shown in the figures.

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EXPLANATION OF PLATES.

PLATE XII. *Haemaphysalis punctata*.

Larva. Dorsal and ventral aspects. $\times 62$.

Drawn from living specimen by J. Ford.

PLATE XIII. *Haemaphysalis punctata*.

Nymph. Dorsal. $\times 30$.

Female, unfed. Dorsal. $\times 20$.

Female, gorged. Dorsal. $\times 5$. Detail of surface more highly magnified, to left.

Female, gorged. Ventral. $\times 5$. Spiracle to right.

Male, unfed. Dorsal. $\times 15$.

Male, gorged. Ventral. $\times 20$.

Male, unfed. Posterior portion of ventral surface, showing appearance of festoons for comparison with those of the gorged male. $\times 20$.

Drawn from living specimens by E. Wilson.

PLATE XIV. *Haemaphysalis punctata*.

Fig. 1. Capitulum of Female. Dorsal aspect. $\times 85$.

Fig. 2. " of Female. Ventral aspect. $\times 25$.

Fig. 3. " of Male. Dorsal aspect. $\times 110$.

Fig. 4. " of Male. Median portion, with left palp. Ventral aspect. $\times 125$.

Fig. 5. " of Nymph. Dorsal aspect. $\times 220$.

Fig. 6. " of Nymph. Ventral aspect. $\times 220$.

Fig. 7. " of Larva. Dorsal aspect. $\times 400$.

Fig. 8. " of Larva. Ventral aspect. $\times 400$.

PLATE XV. *Haemaphysalis punctata*.

Fig. 1. Female. Tactile hairs on infra-internal margin of palp. $\times 250$.

Fig. 2. Male. Ventral surface, showing details of external structures. $\times 30$.

Fig. 3. Larva. Chelicerae, from ventral surface. $\times 1000$.

Fig. 4. Female. Right chelicera, from ventral surface; sheath removed. $\times 250$.

Fig. 5. Male. Left chelicera, from ventral surface. $\times 250$.

Fig. 6. Male. Right chelicera, lateral aspect; sheath removed. $\times 250$.

PLATE XVI. *Haemaphysalis punctata*.

Female. Transverse sections through the capitulum showing the relationships of the chitinous structures. $\times 125$.

Fig. 1. Transverse section at level of digits of chelicerae (chelicera retracted).

Fig. 2. " " " " distal third of hypostome.

Fig. 3. " " " " proximal third of hypostome.

Fig. 4. " " " " base of hypostome.

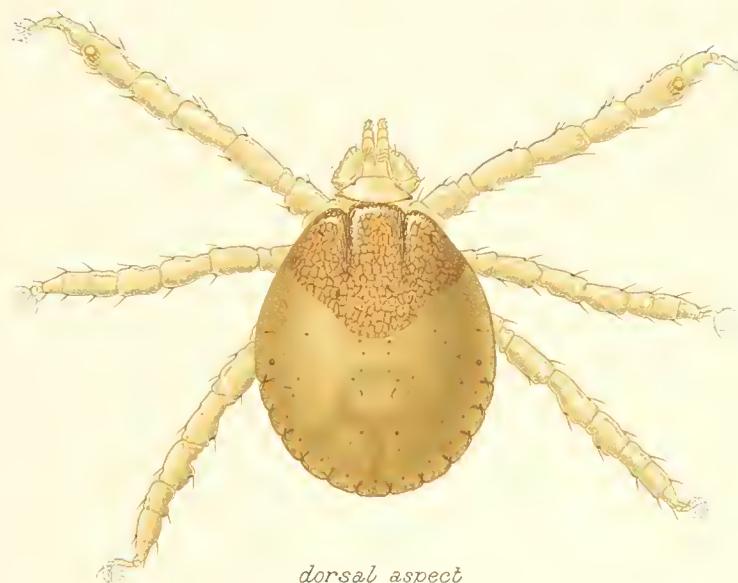
Fig. 5. " " " " insertion of palps.

Fig. 6. " " " " base of palps.

Fig. 7. " " " " anterior margin of porose areas.

Fig. 8. " " " " centre of porose areas.

Fig. 9. " " " " posterior margin of porose areas.



dorsal aspect

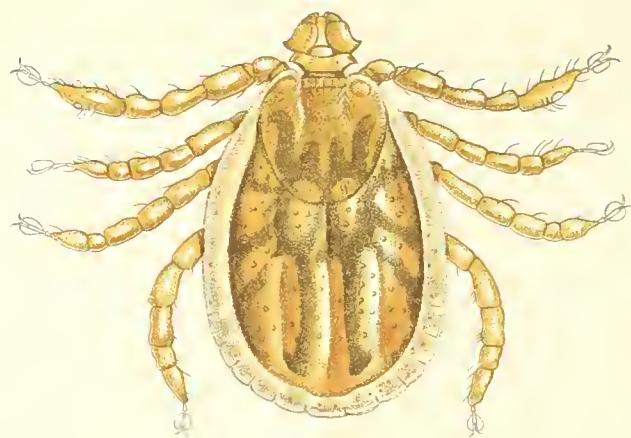


ventral aspect

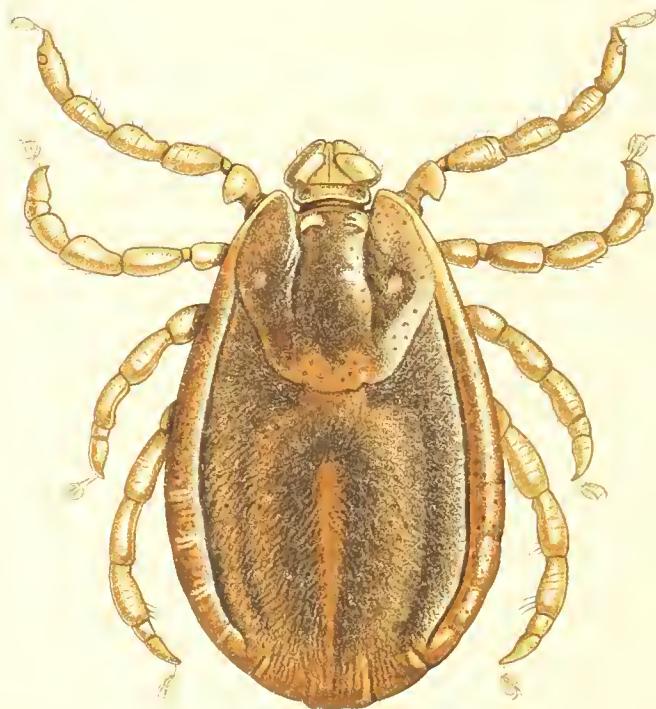
E. Wilson, Cambridge

HAEMAPHYSALIS PUNCTATA Can & Fan.
THE LARVA

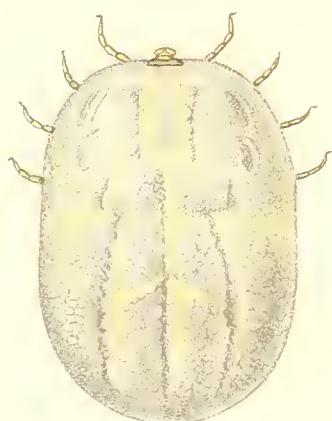




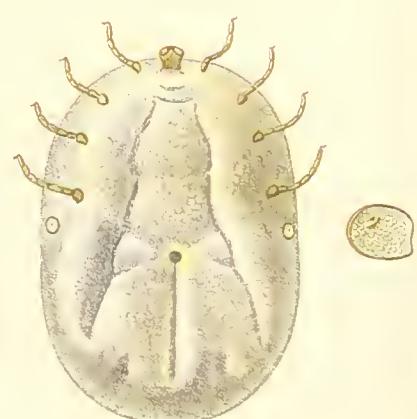
Nymph



Female (*unfed*)



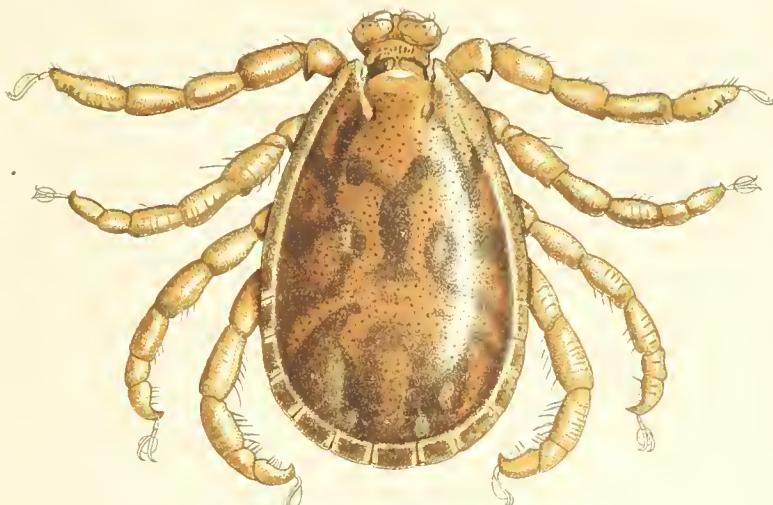
dorsal aspect



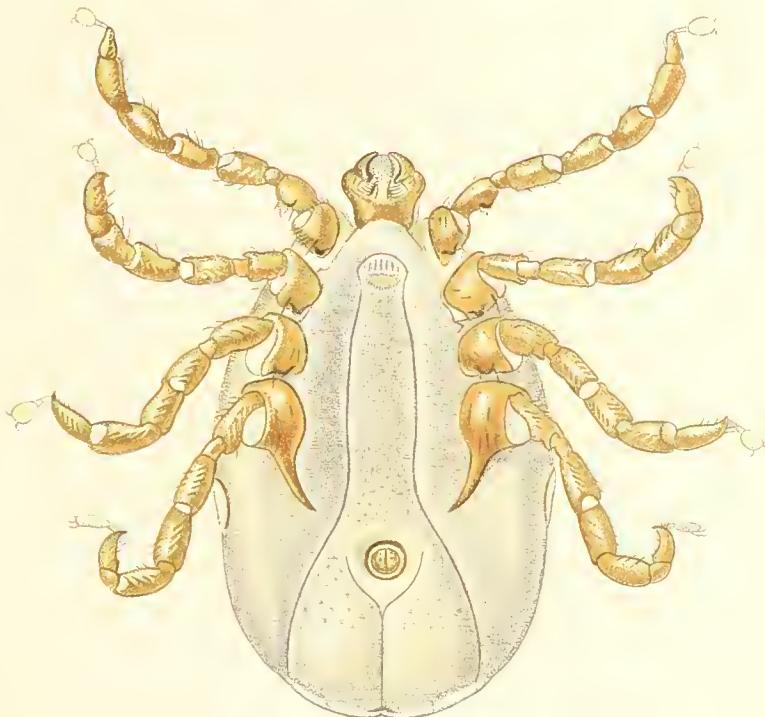
Female (*replete*)

ventral aspect

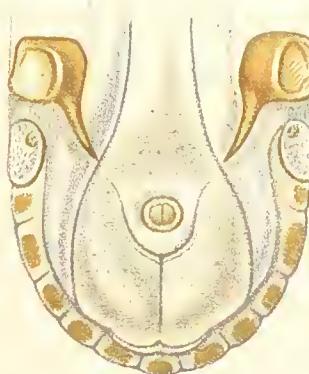
HAEMAPHYSALIS



Male



Male (*replete*)



Male (*unfed*)

E Wilson, del et lith Cambridge.



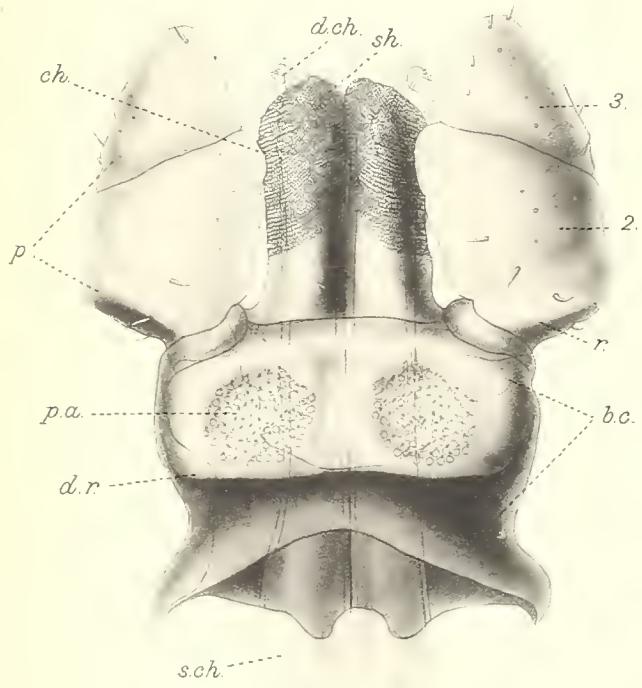


Fig.1.

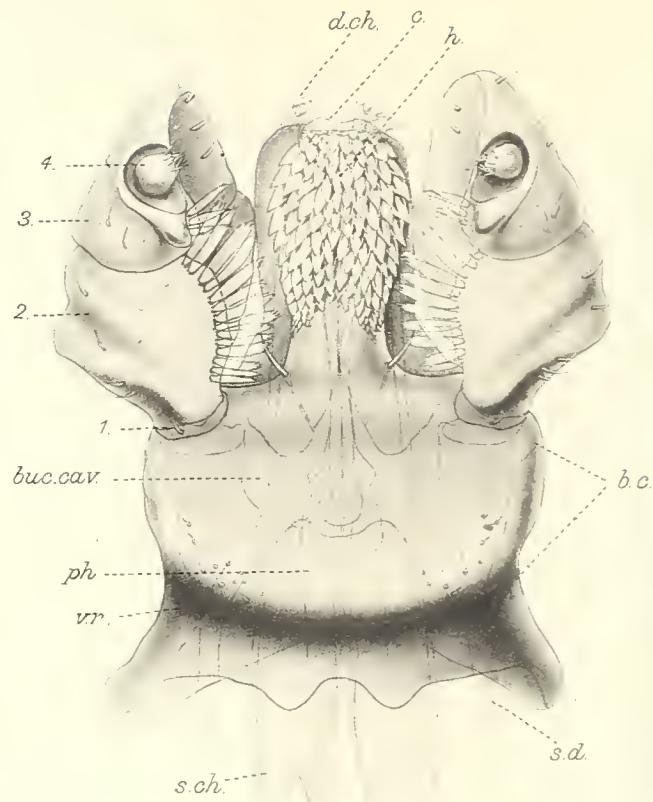
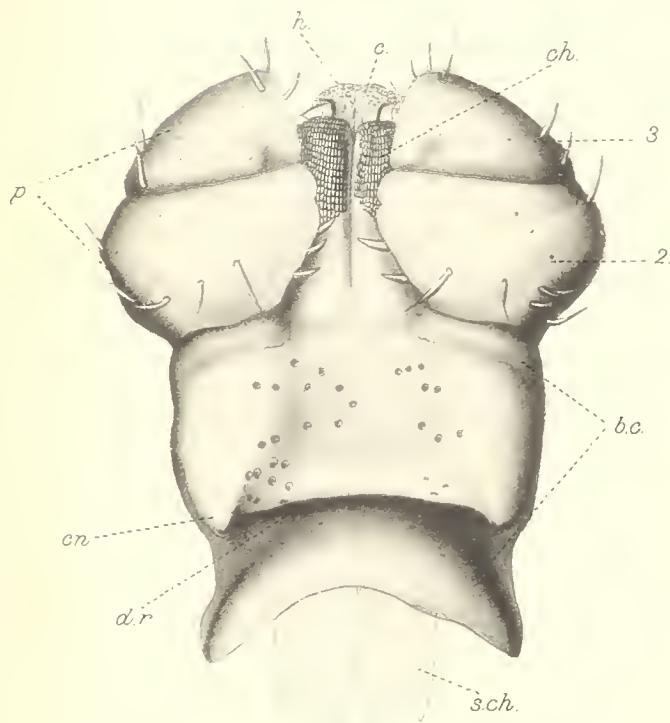


Fig.2.



L E. Rand J. Ford del.

Fig.3.

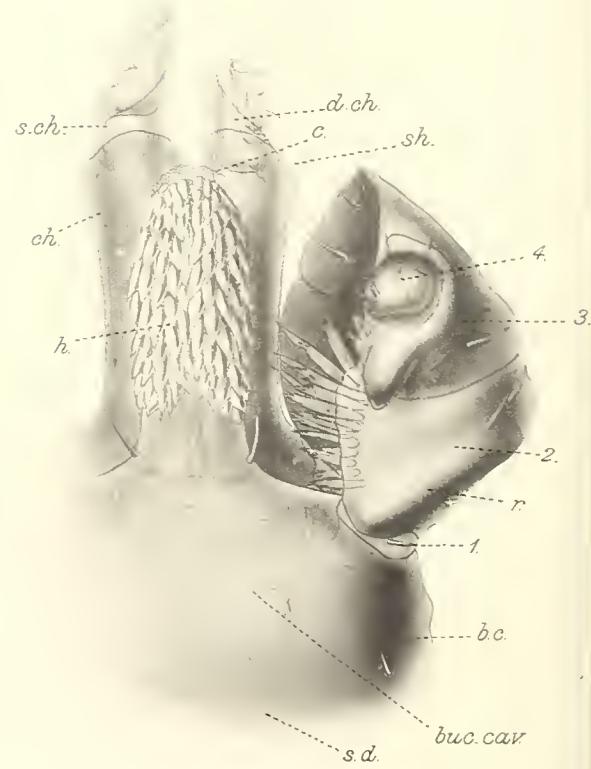


Fig.4.

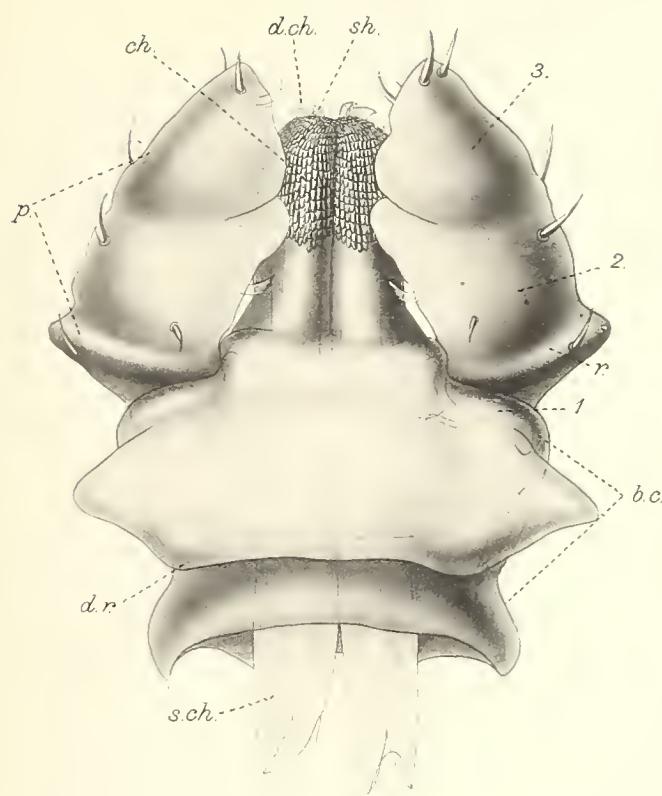


Fig.5.

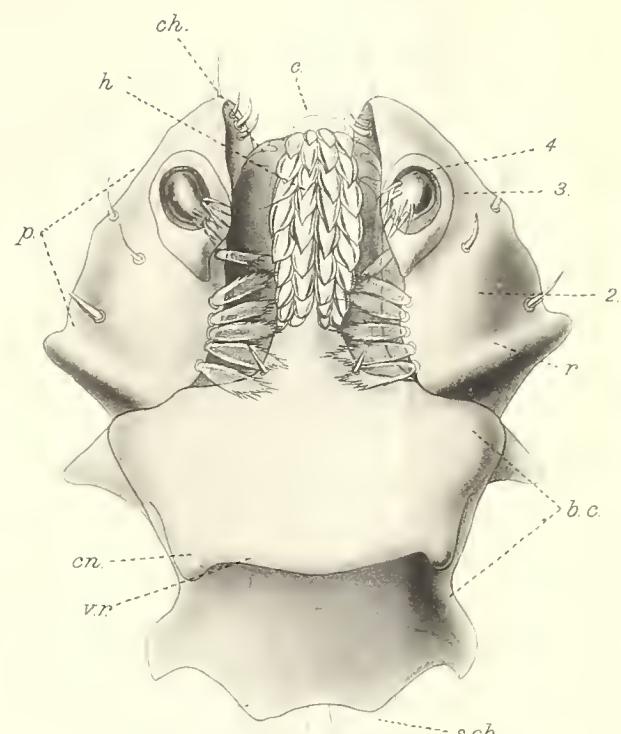


Fig.6.

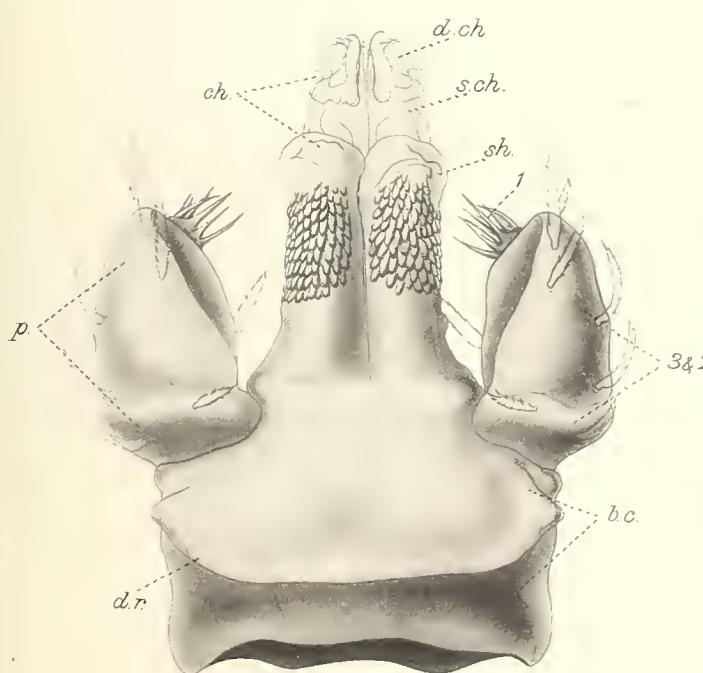


Fig.7.

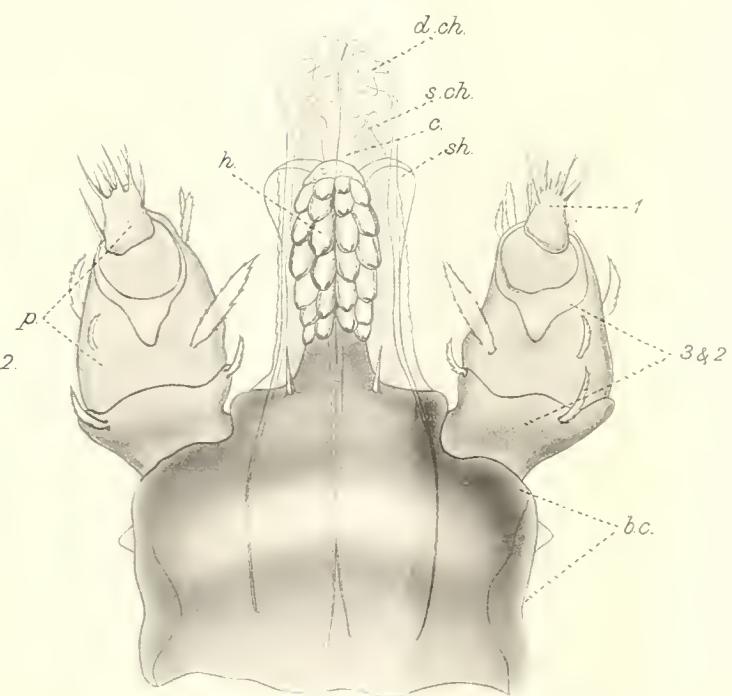


Fig.8.



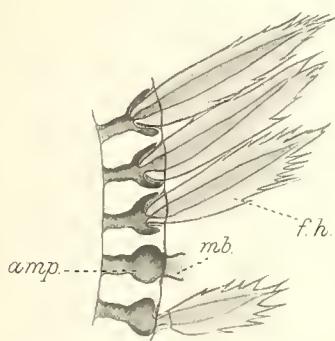


Fig. 1.

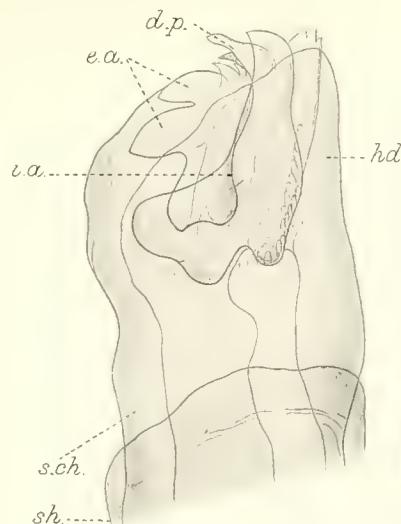


Fig. 3.

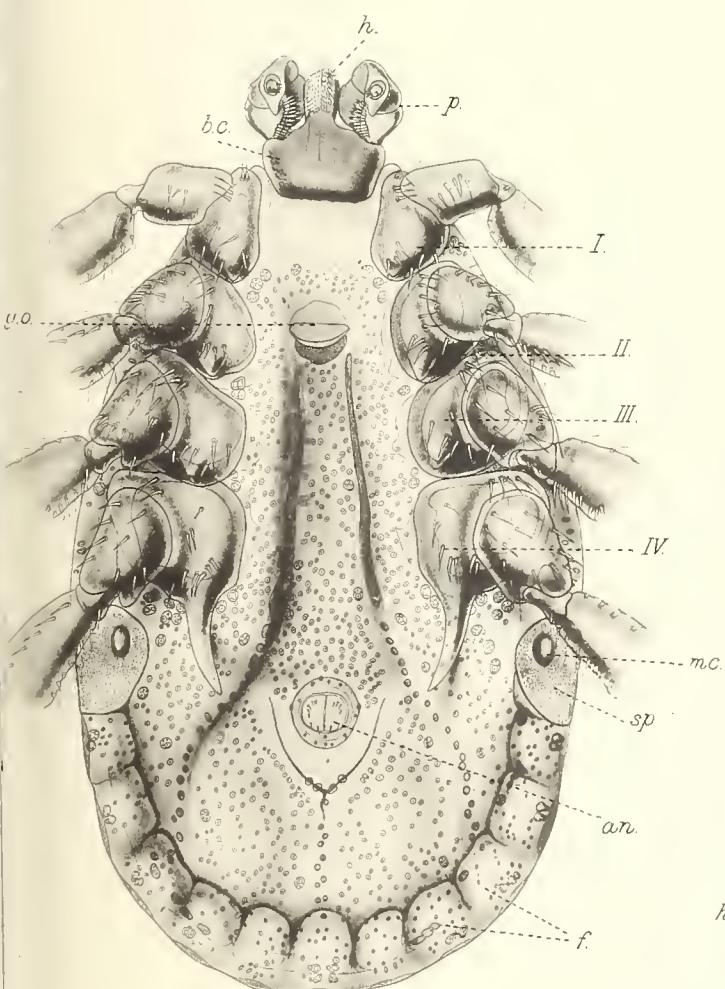


Fig. 2.

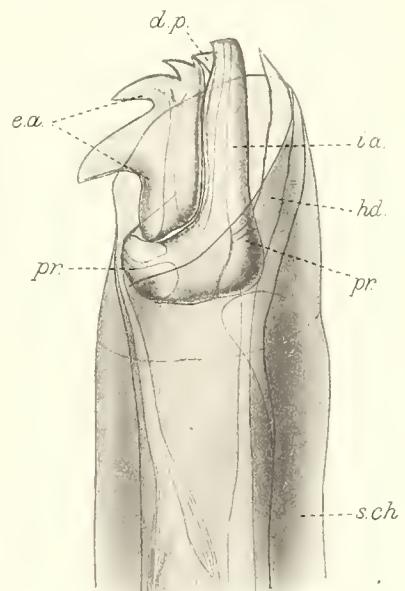


Fig. 4.

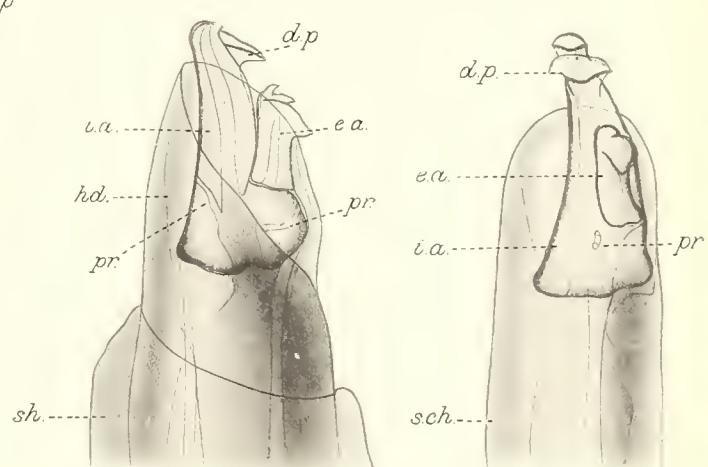


Fig. 5.

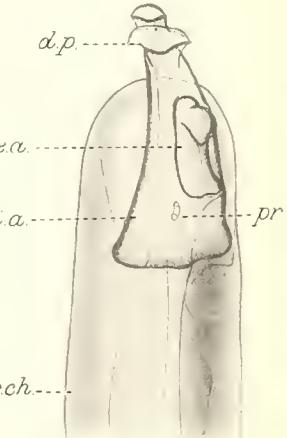


Fig. 6.



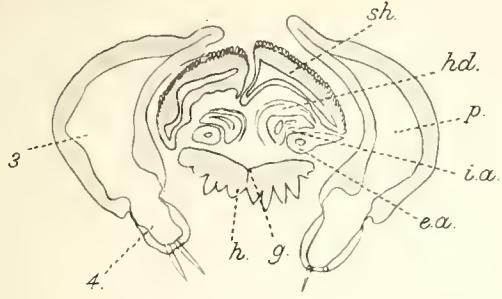


Fig. 1.

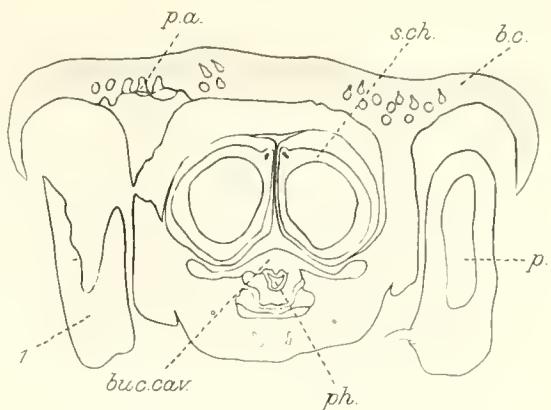


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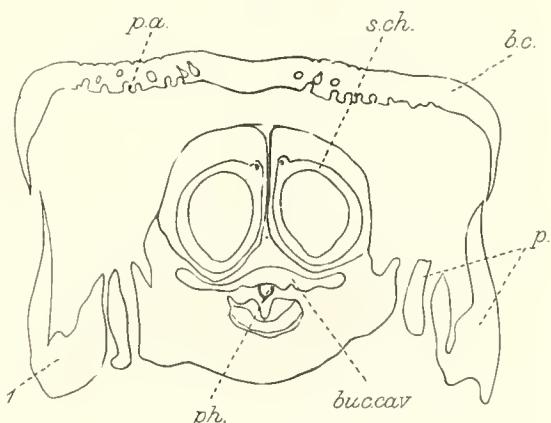


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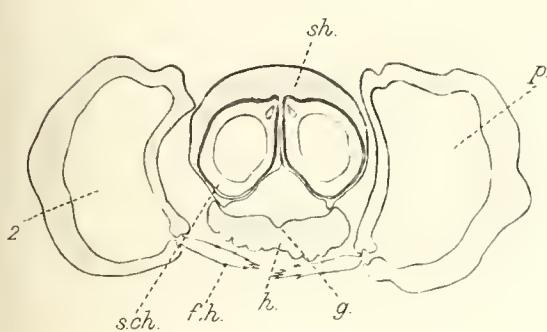


Fig. 3.

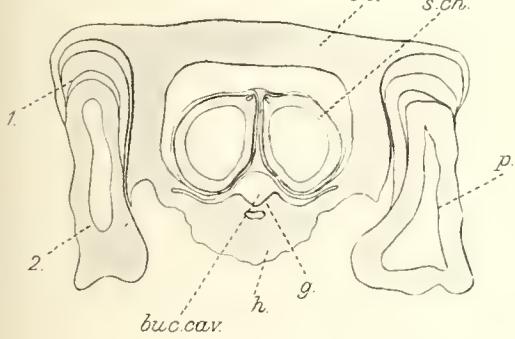


Fig. 4.

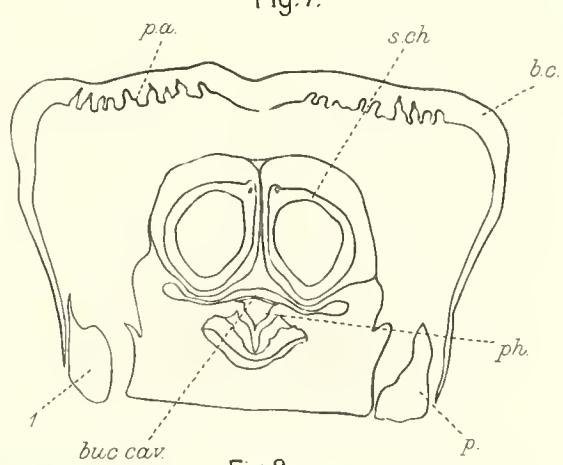


Fig. 8.

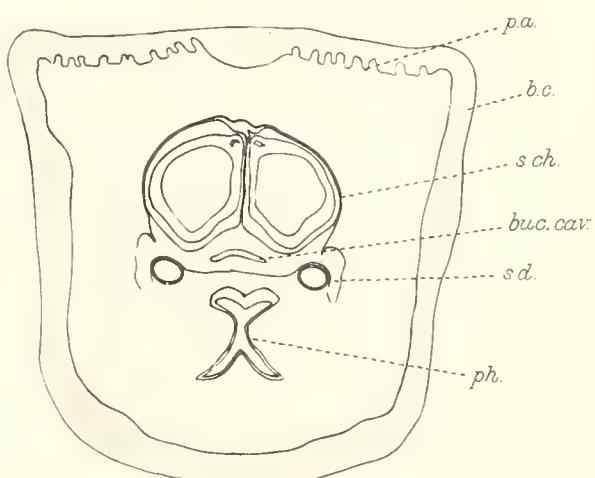


Fig. 9.



INDEX TO LETTERING ON PLATES XIV—XVI.

<i>amp.</i>	ampulla at base of hair.
<i>an.</i>	anus.
<i>b. c.</i>	basis capituli.
<i>buc. cav.</i>	buccal cavity.
<i>c.</i>	corona.
<i>ch.</i>	chelicera.
<i>cn.</i>	cornu.
<i>d. ch.</i>	digit of chelicera.
<i>d. p.</i>	dorsal process.
<i>d. r.</i>	dorsal ridge.
<i>e. a.</i>	external article of digit.
<i>f.</i>	festoons.
<i>f. h.</i>	feather-hair on infra-internal margin of palp.
<i>g.</i>	gutter on dorsal surface of hypostome.
<i>g. o.</i>	genital orifice.
<i>h.</i>	hypostome.
<i>hd.</i>	hood surrounding digit.
<i>i. a.</i>	internal article of digit.
<i>mb.</i>	flexible membranous portion of feather-hair.
<i>p.</i>	palp.
<i>p. a.</i>	porose area.
<i>ph.</i>	pharynx.
<i>pr.</i>	pores on article of digit.
<i>r.</i>	ridge on article 2 of palp.
<i>s. d.</i>	salivary duct.
<i>sh.</i>	sheath of chelicera.
<i>s. ch.</i>	shaft of chelicera.
<i>v. r.</i>	ventral ridge.
<i>I. 2. 3. 4.</i>	articles of palps.
<i>I. II. III. IV.</i>	coxae.

A